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**TERMINAL DISCRETE ADDRESS BEACON SYSTEM/
AIR TRAFFIC CONTROL (DABS/ATC)
TECHNICAL TESTS**

W. Gavin



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MARCH 1980

INTERIM REPORT

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Prepared for

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16. Abstract Tests of the Discrete Address Beacon System (DABS) in an Automated Radar Terminal System (ARTS III) environment were conducted at the National Aviation Facilities Experimental Center (NAFEC). To date, surveillance performance has been tested in evaluation areas of track swap, track initiation, and track loss. Surveillance-related communications, including Common International Civil Aviation Organization (ICAO) Data Interchange Network (CIDIN) protocol, have also been tested. Initial tests were conducted using the Air Traffic Control Simulation Facility (ATCSF) to generate simulated DABS and Air Traffic Control Radar Beacon System (ATCRBS) targets. Results of tests in both surveillance and surveillance-related communications have proven compatibility between DABS and the modified ARTS. To introduce the actual DABS sensor into the testing, the Aircraft Reply Interference and Environment Simulator (ARIES) was used to simulate aircraft replies from DABS and ATCRBS transponders. The replies were processed by DABS to generate DABS and ATCRBS target reports and transmitted to the Air Traffic Control (ATC) facilities. Results of these tests showed that surveillance performance did not vary significantly from that of the earlier tests. More testing of the surveillance-related communications functions using ARIES/DABS inputs will be required before performance in this area can be adequately characterized. This is an interim report, consequently, some of the reported results are of a preliminary nature and have raised questions which are being investigated further.		
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons	0.9	tonnes	t
	(2000 lb)			
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	yards	yd
		0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	35	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



* For 1.254 exactly. For other exact conversions and more data and tables, see NIST Mon. Publ. 286, *Units, Weights and Measures*, Price \$2.25, SO Catalog No. C-11-286.

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INTRODUCTION

PURPOSE.

The purpose of this testing was to characterize the technical performance of the Discrete Address Beacon System (DABS) in an Automated Radar Terminal System (ARTS) environment. Results from these tests will be used in the preparation of the first DABS Technical Data Package (TDP) and the ARTS software/hardware TDP to be completed in early 1980.

BACKGROUND.

The DABS is being developed by the Federal Aviation Administration (FAA) to upgrade the existing Air Traffic Control Radar Beacon System (ATCRBS). DABS provides increased capacity, better azimuth measurement precision, and reduced interference between sensors due to reduced interrogation rates as compared to ATCRBS. In addition, for aircraft equipped with DABS transponders, the system provides ground-to-air and air-to-ground data transmission capabilities which are the basis for automated air traffic control (ATC) functions. One of these is the ground-based conflict resolution system, called the Automated Traffic Advisory and Resolution Service (ATARS).

One of the major aspects of DABS development is the requirement that the system be capable of interfacing with existing ATC terminal facilities. Accordingly, functional and procedural changes are being made to the existing ARTS to accommodate DABS. A special version of the ARTS all-digital program, known as the Tampa/Sarasota System, was used as a reference model from which changes were made. The test bed at the NAFEC Terminal Automation Test Facility (TATF) was reconfigured for DABS in fiscal year 1978.

Changes to the Tampa/Sarasota program are being implemented in three stages. The first stage provided the capability to accept and process all DABS surveillance messages; the second stage includes specific surveillance-related communications messages (e.g., ATCRBS Identification (ID) code request message); and the third stage will process all DABS communications messages and will include software necessary to interface ARTS with the ATC En Route System. Tests of the first and second stages are discussed in this report. Tests of the third stage will be discussed in a subsequent report.

DESCRIPTION OF EQUIPMENT.

To conduct tests of the DABS in an ARTS environment, three test configurations of the modified ARTS with DABS inputs were used. These test configurations constitute combined DABS/ARTS systems. A test configuration with the NAFEC Air Traffic Control Simulation Facility (ATCSF)-generated DABS surveillance data in a surveillance-only mode is shown in figure 1. For the initial testing of communications functions, a test configuration with the ATCSF online is shown in figure 2. Finally, for tests with the DABS sensor itself, the test configuration is shown in figure 3. A discussion of each of the major items comprising the configurations is provided as follows.

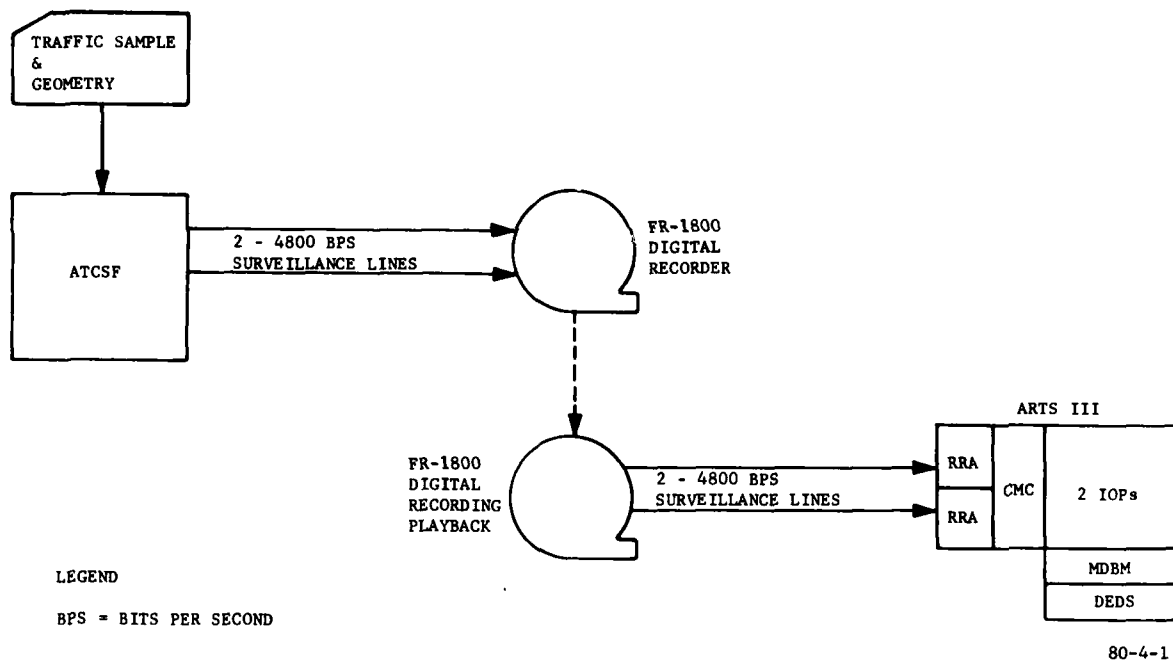


FIGURE 1. TEST CONFIGURATION FOR ATCSF, SURVEILLANCE-ONLY TESTS (ARTS DELIVERY 1 SOFTWARE)

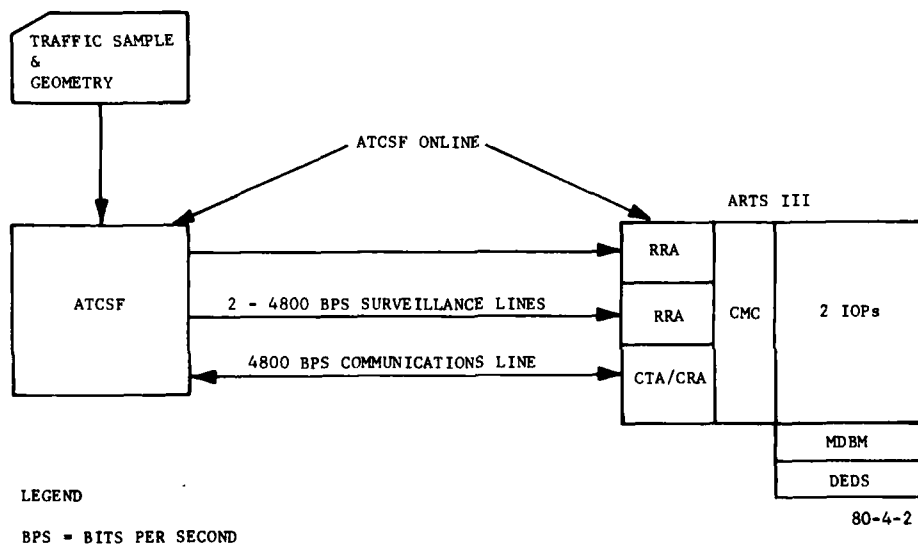


FIGURE 2. TEST CONFIGURATION FOR ATCSF, COMMUNICATION TESTS (ARTS DELIVERY 2 SOFTWARE)

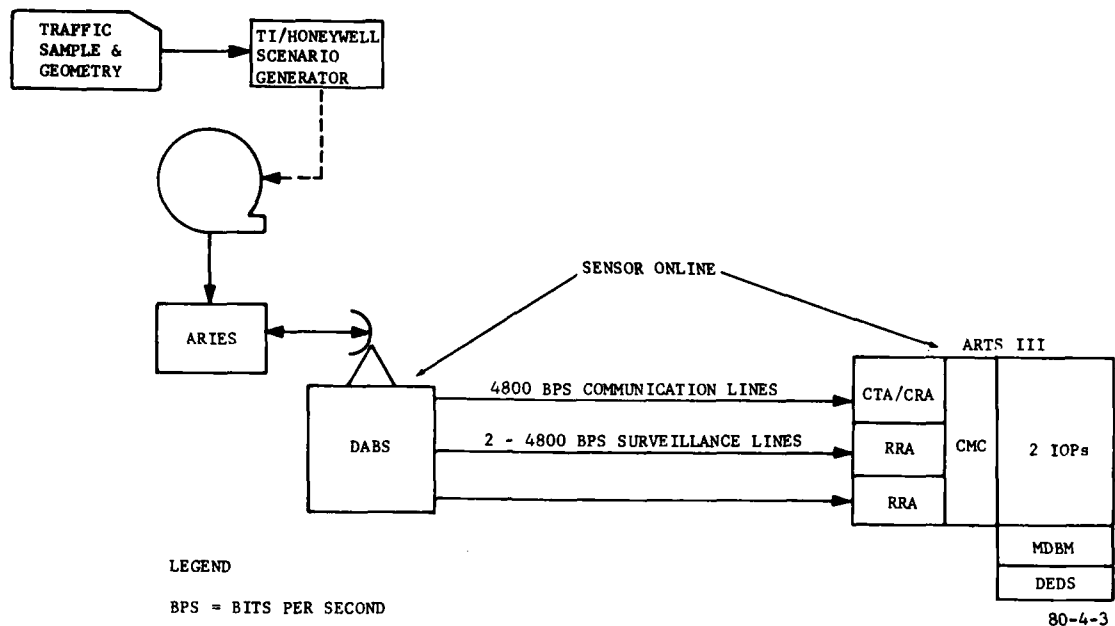


FIGURE 3. TEST CONFIGURATION FOR ARIES TESTS (ARTS DELIVERY 2 SOFTWARE)

TERMINAL AUTOMATION TEST FACILITY. The major elements in the TATF test bed reconfigured for DABS are as follows:

1. Input/Output Processor (IOP)—provides the basic processing capability for the TATF with access to 256,000 words of memory.
2. Communications Multiplexor Controller (CMC)—provides modulator-demodulator (modem) link interface for up to 16 full duplex or 32 simplex devices and controls and formats modem data for the IOP.
3. Radar Receiver Adapter (RRA)—provides surveillance data transfer from the modem to the IOP via the CMC.
4. Common International Civil Aviation Organization (ICAO) Data Interchange Network (CIDIN) Receiver Adapter (CRA)—accepts communications data from the modem receiver and transfers it to the IOP via the CMC.
5. CIDIN Transmitter Adapter (CTA)—outputs communications data from the IOP to the modem via the CMC.

6. Data Entry and Display Subsystem (DEDS)—provides keyboard data entry with colocated displays.

7. Multiplexed Display Buffer Memory (MDBM)—provides storage capability for display refresh data, controls data entry for up to four DEDS, and monitors data transfers with the IOP.

A more detailed description of the ARTS III system hardware may be found in FAA Report ARD-140-17-79 (reference 1).

DISCRETE ADDRESS BEACON SYSTEM SENSOR. The DABS sensor consists of three major subsystems: the interrogator and processor (I&P) subsystem, the computer subsystem, and the communications subsystem. A fourth subsystem, the data extraction subsystem, extracts and analyzes the data produced by the major subsystems of the sensor.

The I&P subsystem consists of the antenna, transmitter, receiver, and processor units. This subsystem accomplishes the pulse-processing function and provides the interface to the ARIES.

The computer subsystem consists of eight DABS computers, together with global memories and interconnecting hardware. The internal processing functions of the sensor, including channel management, surveillance processing, and network management are accomplished by software which resides in this subsystem.

The communications subsystem includes three DABS computers along with the various interface circuitry and modems required to prepare and transmit the processed surveillance and communications or data link messages between the DABS sensor and the ATC facilities.

These subsystems, together, provide all of the hardware and software functions of the DABS sensor. A more detailed discussion of these functions may be found in FAA Report RD-74-189 (reference 2).

AIRCRAFT REPLY INTERFERENCE AND ENVIRONMENT SIMULATOR. ARIES is designed to simulate a radar beacon environment of up to 400 transponders (ATCRBS and DABS) plus high rates of interfering beacon replies (fruit). In particular, ARIES is designed to test DABS sensors.

Components of the ARIES system are controlled and interfaced by a 16-bit minicomputer (Data General, Eclipse S/200), with 32,000 words of core and with high-speed, input/output (I/O) interface capability. Peripherals include a teletype for providing operator communications, and a disc cartridge and magnetic tape for storing the system's programs and the ARIES-controlled traffic model.

AIR TRAFFIC CONTROL SIMULATION FACILITY. By use of its Sigma 5 and Sigma 8 computers and associated minicomputer (Alpha-16), the ATCSF can provide the following functions: (1) aircraft flight generation/simulation, (2) radar and beacon simulation, (3) ATC simulation, and (4) pilot simulation.

The simulation software has been designed to accommodate up to 300 simultaneous simulated targets, 12 radar or beacon sites, 480 navigational aids or fixes, and 700 route segments. Radar and beacon returns can be simulated by indicating 1 to 12 radar or beacon sites (including three DABS sites, plus ATCRBS sites) and antenna scan time, resulting in both production common digitizer (PCD) and DABS/ATCRBS-formatted surveillance messages. Hardware is provided which allows both pilot and ATC simulation.

The Sigma computers each have access to 96,000 words of memory. Four Alpha-16 minicomputers drive pilot displays, interpret and validate pilot keyboard messages, and communicate to the Sigma computers.

Communications equipment provides for the transmission of digitized and formatted data between the ATCSF and National Airspace System (NAS) En Route and the ATCSF and ARTS.

For a more detailed description of the ATCSF and its capabilities, see reference 3 through 5.

DISCUSSION

METHOD OF APPROACH.

Technical test and evaluation of the combined DABS/ARTS system to date has been conducted in the test area of track identification which is concerned with system performance relative to the timely and correct identification of aircraft. The areas of evaluation directly concerned with identification are track swap, track initiation, and track loss.

Testing of track identification has been accomplished via the following tests:

1. Tests of ARTS Delivery 1 software (surveillance only) using ATCSF-generated surveillance data (figure 1).
2. Tests of ARTS Delivery 2 software interfaced with the ATCSF, including the surveillance-related communications capability (figure 2).
3. Tests of ARTS Delivery 2 software using the DABS sensor with ARIES inputs in a surveillance and surveillance-related communications message environment (figure 3).

The scenarios used in tests in items 1 and 2 above were generated by the ATCSF. However, the ATCSF could not be used for tests in item 3 because the capability to simulate a stationary test target in an ARIES aircraft traffic model did not exist. Instead, tests in item 3 were generated using the TI/Honeywell scenario generator. The requirement to simulate a stationary test target is important since ARTS modified for DABS requires a periodic transmission of the test target to synchronize ARTS with the DABS antenna. However, the same scenario flight profiles were used for each series of tests.

The scenarios used for track initiation and track loss evaluations contain straight line and turning flights. These flight profiles are depicted in figures 4 and 5. The scenarios contain both DABS and ATCRBS aircraft and were repeated for the different velocities as indicated.

The scenarios used for track swap evaluation contain flight profiles for overtaking aircraft, head-on crossings, and 30° crossings. Aircraft types included both DABS and ATCRBS but concentrated heavily on nondiscrete ATCRBS codes because it was suspected that swaps would most likely occur with these codes. These flight profiles are depicted in figures 6 through 8.

The flight profiles depicted in figures 4 through 8 are similar to those used in tests of the ARTS III Radar Beacon Tracking Level (RBTL) described in MTR-7300 (reference 6). Similar flight profiles were chosen so that test results could be compared to those for an existing ARTS system.

Scenarios were also generated which contained different cases involving the surveillance file number (SFN) changes of an ATCRBS track. These were included to evaluate the effectiveness of the ARTS software in handling SFN changes and, conversely, to evaluate sensor SFN change characteristics. The SFN is the primary means of correlating sensor-tracked ATCRBS reports with ARTS tracks.

During the test of ARTS Delivery 1 software, surveillance messages generated by the ATCSF were transmitted on surveillance lines and recorded on the FR-1800 digital recorder. Test missions of 2 to 2 1/2 hours duration were conducted in a playback mode using the different recordings as input to the modified ARTS system.

These tests employing the ATCSF were conducted with the following conditions:

1. Target Report Positional Accuracy
 - a. DABS and ATCRBS Beacon Reports
 - Range : 50 feet
 - Azimuth: 0.1°
 - b. Search Reports
 - Range: 110 feet
 - Azimuth: 0.18°
2. Blip/Scan
 - a. Beacon and Search Reports: 0.95

All test missions consisted of from three to six sequences of tests or test segments.

All tests of ARTS Delivery 1 software were conducted with radar-reinforced beacon.

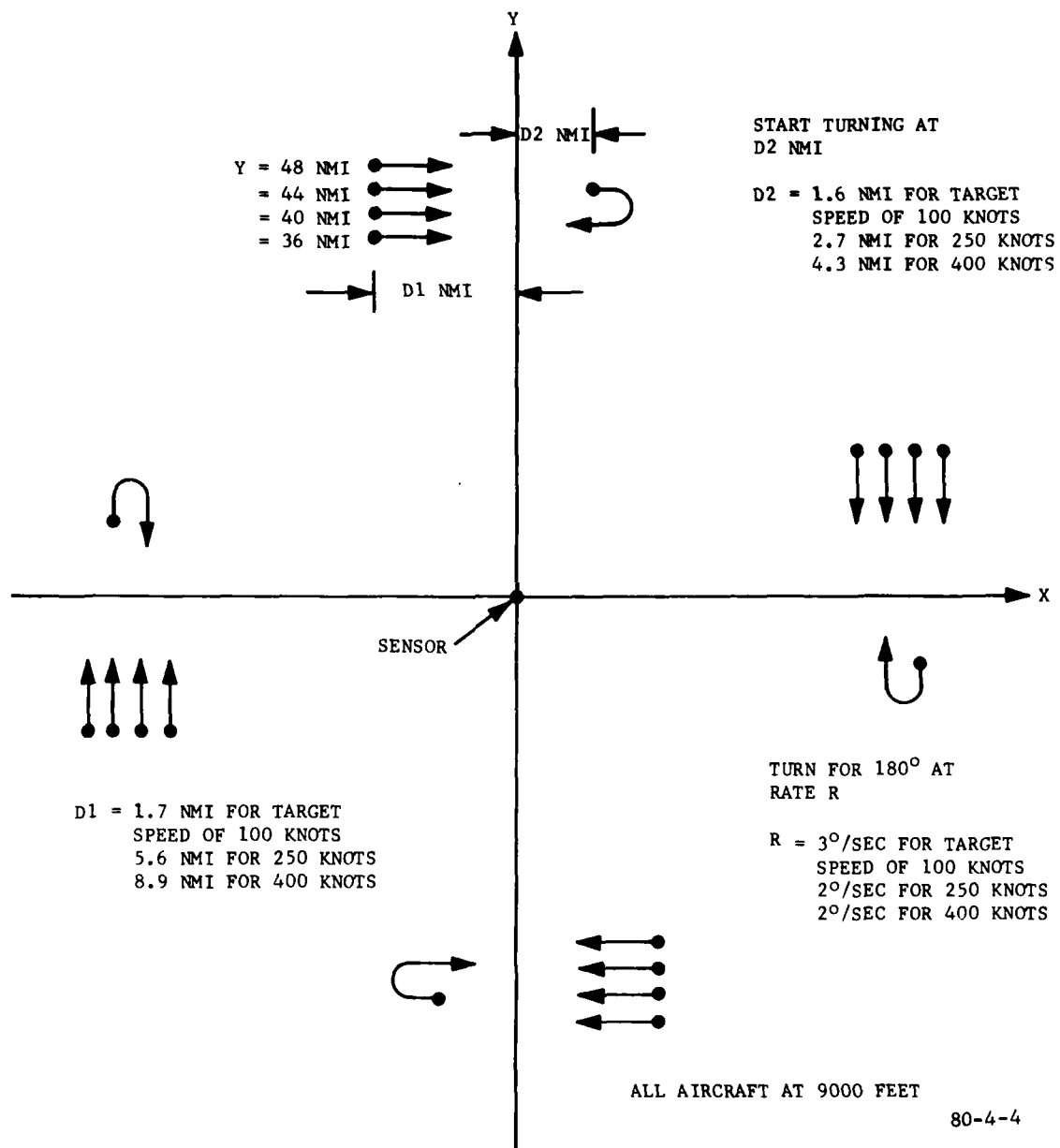
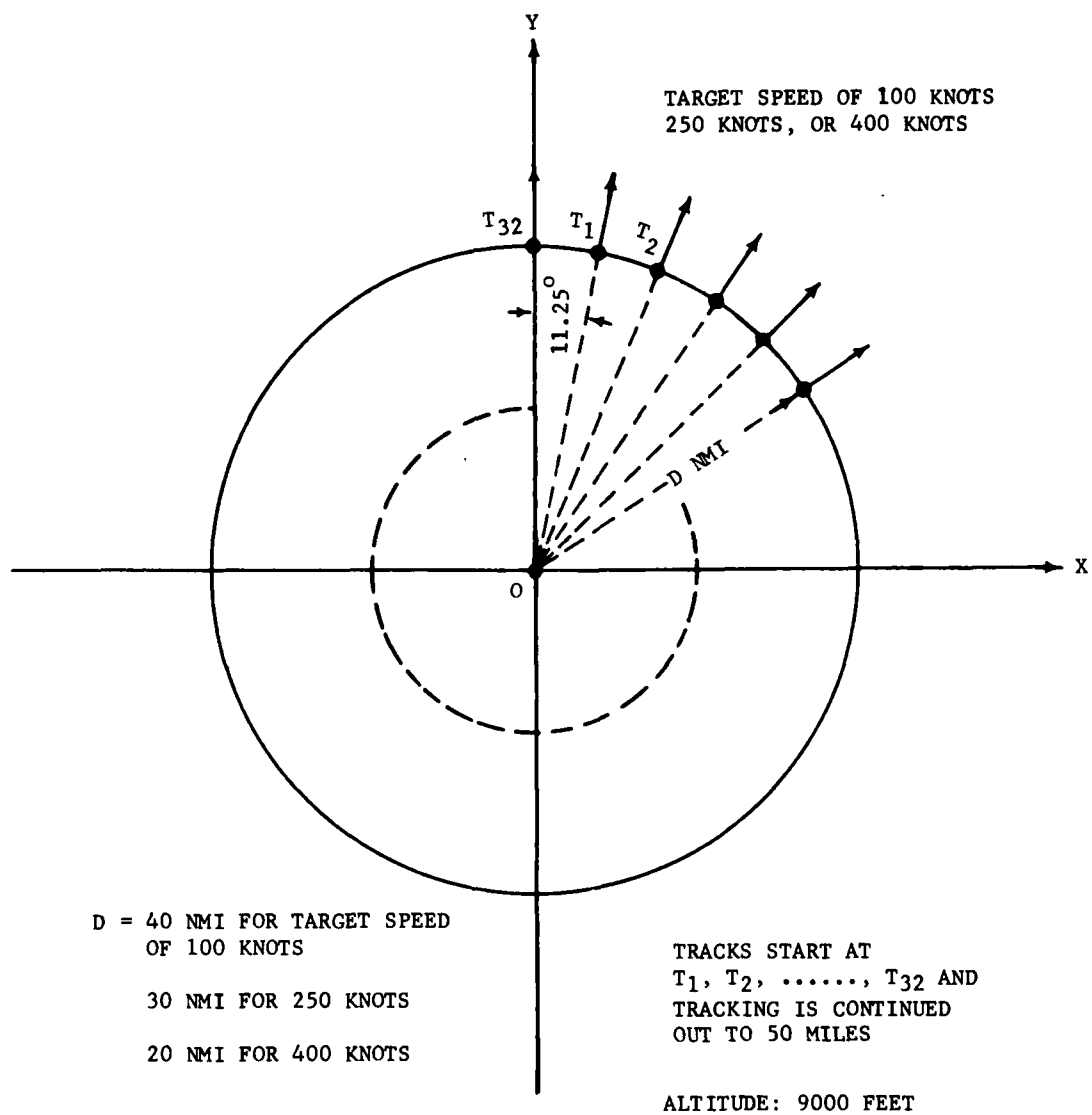
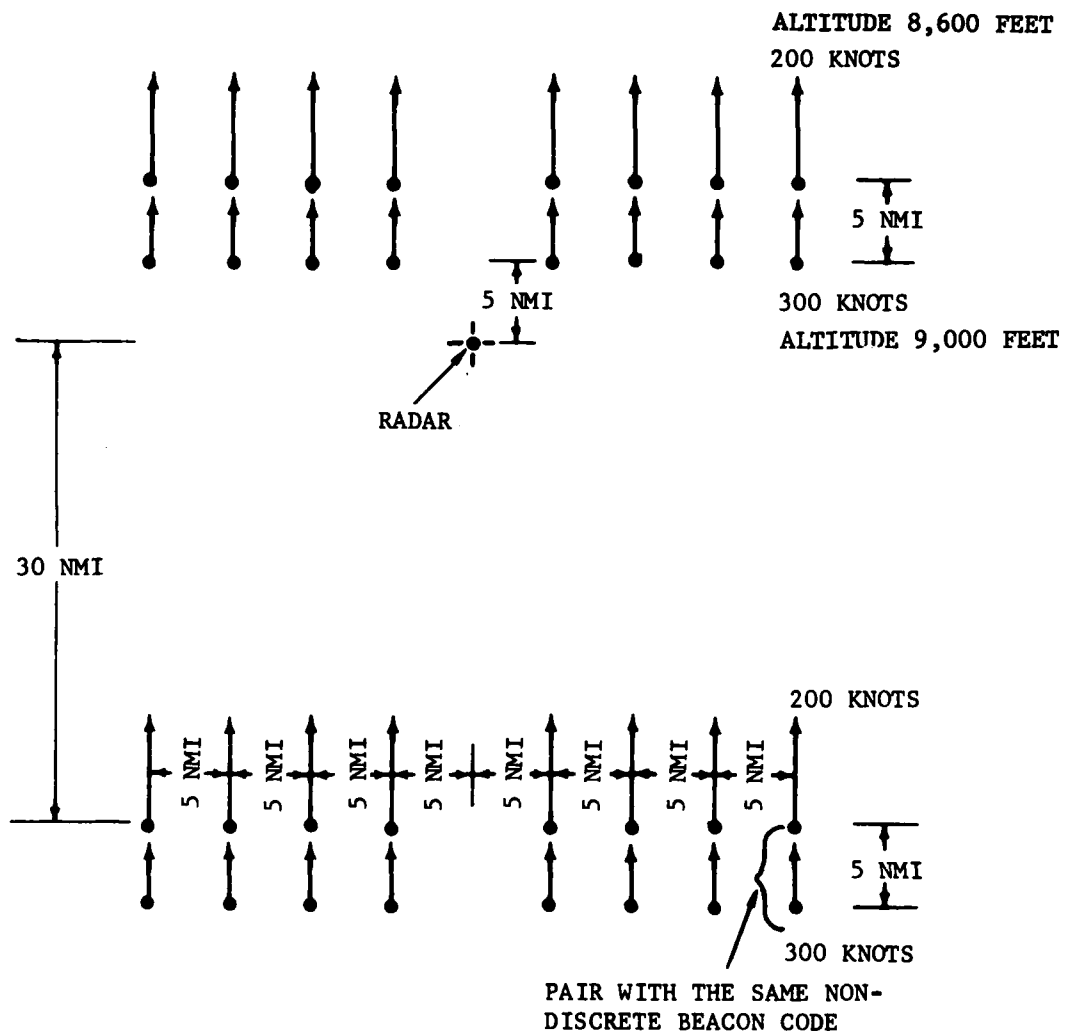


FIGURE 4. TARGET SCENARIO FOR THE EVALUATION OF TRACKING PERFORMANCE IN STRAIGHT-LINE FLIGHT—TARGET HEADING AND AZIMUTH IN QUADRATURE—AND FOR TRACKING PERFORMANCE IN TURNS



80-4-5

FIGURE 5. TARGET SCENARIO FOR THE EVALUATION OF TRACKING PERFORMANCE IN STRAIGHT-LINE FLIGHT—TARGET HEADING IN LINE WITH AZIMUTH



80-4-6

FIGURE 6. TARGET SCENARIO FOR THE EVALUATION OF SWAP PERFORMANCE—OVERTAKING TRACKS

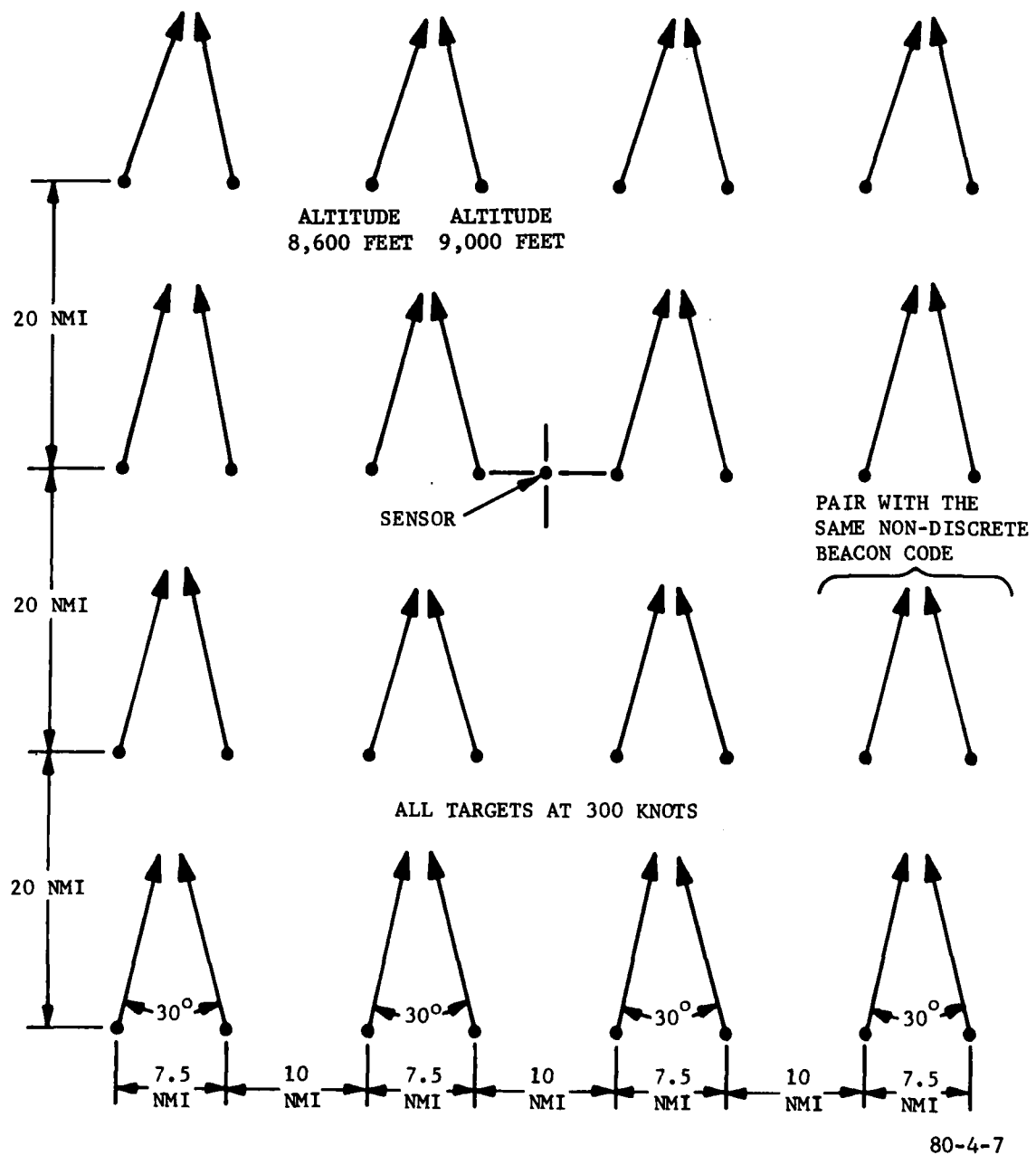


FIGURE 7. TARGET SCENARIO FOR THE EVALUATION OF SWAP PERFORMANCE—30° CROSSING TRACKS

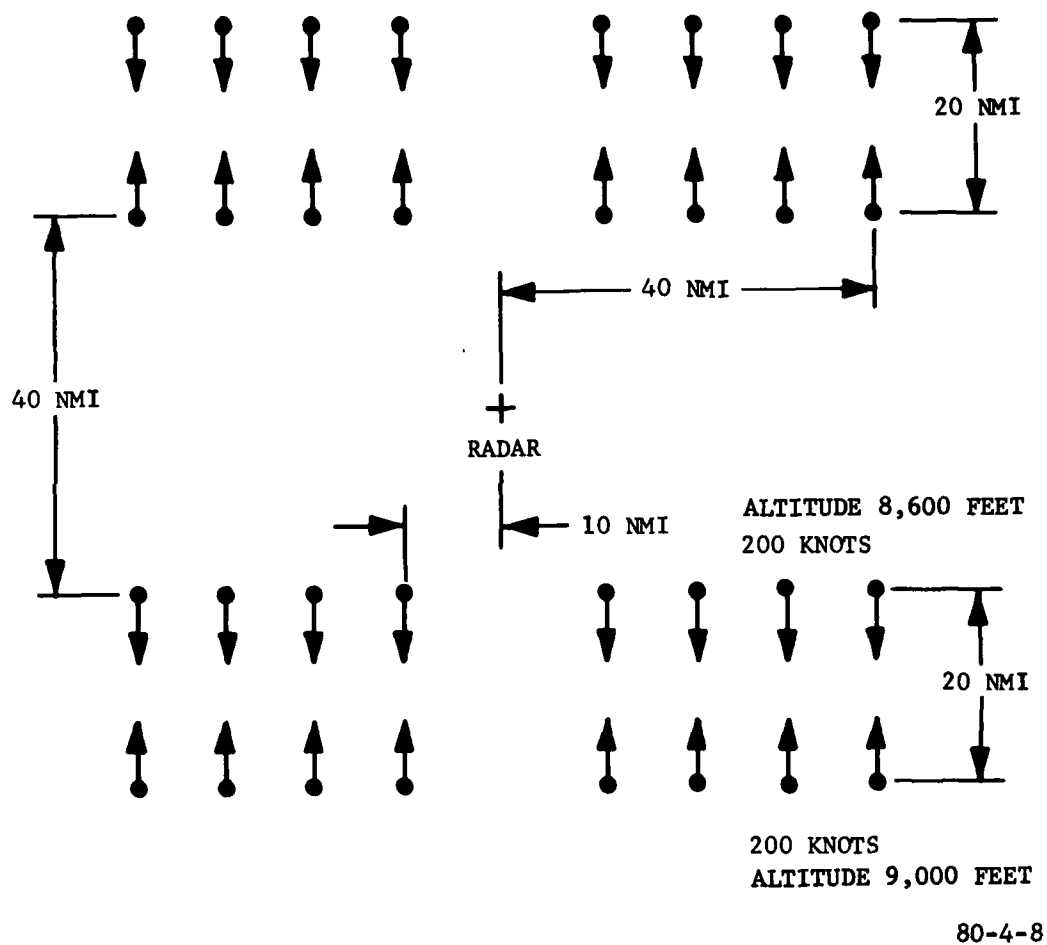


FIGURE 8. TARGET SCENARIO FOR THE EVALUATION OF SWAP PERFORMANCE—HEAD-ON CROSSINGS

Tests of ARTS Delivery 2 software with ATCSF inputs were conducted with a subset of the scenarios generated for the Delivery 1 tests. In addition, ATCRBS ID code changes were implemented at the ATCSF simulator pilot's consoles to test functions of surveillance-related communications.

Tests of ARTS Delivery 2 software with ARIES were conducted using Delivery 2 software connected online to the DABS sensor. The scenarios generated were for a beacon-only environment.

No positional accuracy (or jitter) was included in the ARIES scenarios since ARIES itself has inherent error. The ARIES tests were conducted with the following conditions:

1. Nominal fruit of 4,000/second for ATCRBS and 50/second for DABS,
2. Reply probabilities of 68 percent and 95 percent.

The above values were obtained by consulting with DABS sensor performance test personnel. This was done to take advantage of their experiences and to use proven ARIES and sensor performance characteristics.

DATA COLLECTION.

Data collection was accomplished both automatically and manually. Manual data collection was accomplished via test team logs of ARTS display observations. For the most part, ARTS continuous data recording (CDR) software was used to automatically extract test data. ARIES recording and DABS extractor programs were periodically used to verify ARIES inputs to DABS and DABS outputs to the TATF, respectively.

Displays were observed for incidences of tracks failing to initiate and associate, track loss, and track swap.

Tracks were considered to have failed to initiate when no symbol for the target appeared in the expected target position, and were considered to have failed to associate when no controller symbol or data block appeared or immediately dropped at the target position.

Track losses occur when: (1) the initiated and not-yet-associated track is dropped completely after failing to correlate with target reports from the sensor or ATCSF for three consecutive scans or (2) when an associated track goes to tabular coast after 10 consecutive failures to correlate. Since this was not always easy to observe on the display, track losses were determined from the ARTS data reduction.

Track swaps were considered to have occurred when the aircraft identity (ACID) of one proximate track switched its identity to the surveillance data of another. This was easily observed on the display and was verified in the data reduction. In general, most display observations were verified by data reduction. Data reduction was also used to determine the number of scans

required for initiation and association and to analyze results of the effects of SFN changes. The data obtained from ARTS extraction for all analyses were: surveillance messages, communication messages, tracking data, keyboard input data, and central track store (CTS) files.

To evaluate the surveillance-related communications, ARTS data reduction was used to analyze the consequences of ATCRBS code changes and their relationship to ATCRBS ID code messages. Although the ARTS software was configured to send ATCRBS ID request messages every 30 seconds, a software patch was requested to reduce the request frequency so that the effect of the ATCRBS ID request message could be more easily determined from the data reduction. Overall analysis and evaluation of DABS/ATC communications were concerned with time delays, message frequency, and message content errors.

RESULTS AND ANALYSES.

ATCSF/ARTS DELIVERY 1. Results from this test series are reported in two parts. The first part reports on tests conducted in the evaluation areas of ARTS track initiation, track loss, and track swap which showed the modified ARTS capable of accepting and processing simulated DABS inputs (surveillance only). The second part reports on tests conducted to determine ARTS reaction to DABS sensor SFN changes which led to identification of problems in the ARTS Thresholded Alpha Beta Gamma (TABG) tracker and related software.

The overall objective of the first test series using the ATCSF was to provide an initial assessment of the performance of the integrated DABS/ARTS system under ideal conditions of perfect track/report correlation, error-free code, and an environment without interference. Additional objectives were to determine the effectiveness of the ARTS software logic in handling SFN changes and to determine the combined effectiveness of the DABS sensor and ARTS in handling successive target misses.

Part 1—Track Identification. As a result of display observation followed up by analysis of data reduction printouts, it was observed and verified that after initiation and association had occurred there were no track losses and no track swaps. This was based on repeated samples of track pairs. In most cases the target symbol is displayed immediately upon receiving the target surveillance message. Identification of the aircraft with correct flight plan information (association) would normally occur a short time later (usually within the same scan). However, successful track initiation is not considered to have occurred until the track firmness level equals four (about three scans after target receipt and flight plan association). At this level, all of the track smoothing parameters in the ARTS TABG tracker have been activated. Observing that successful initiation occurred regardless of the speed, flight-path, type aircraft, positional accuracy, or blip/scan, data from these various categories were lumped together and are presented in figure 9. This shows that about 90 percent of the tracks were initiated and associated three scans after the targets were first detected by ARTS, which is in substantial agreement with theoretical expectations. The 10 percent not meeting theoretical expectation is due to simulated noises and a blip/scan ratio less than 1.

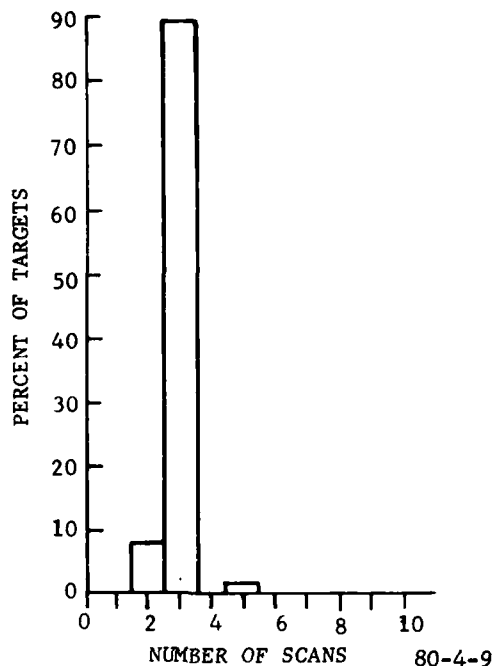


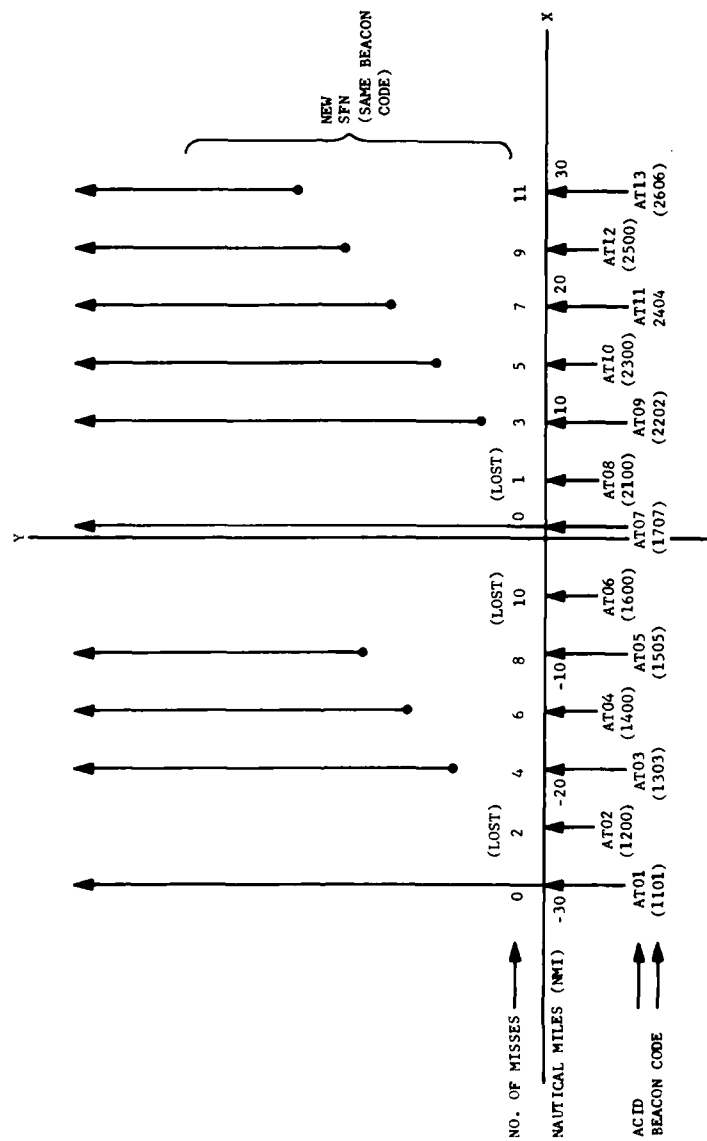
FIGURE 9. NUMBER OF SCANS TO TRACK INITIATION—ATCSF

Part 2—SFN Change Tests. ARTS matches the SFN of an ATCRBS target report with the SFN stored for a particular ATCRBS track. Should a sensor tracking problem occur and an ATCRBS track is lost, it is possible for ATCRBS target reports from one aircraft to be tagged with different SFN's. The SFN can change for a given aircraft.

Figure 10 shows a straight-line scenario used in the special SFN change tests. This scenario consists of 13 targets which start below the X-axis with a heading of 0°. Both discrete and nondiscrete ATCRBS codes are represented. Simulated misses begin when the targets reach the X-axis.

A turn scenario was also used. It is similar to the straight-line scenario with the exception that the misses occur during a 90° turn. After the misses in both scenarios, each target reappears with a different SFN but with the same code.

Detailed analysis of the results revealed three problems in the ARTS software which are discussed in succeeding paragraphs:



80-4-10

FIGURE 10. STRAIGHT-LINE SCENARIO SHOWING TRACKS BY NAUTICAL MILE FOR SURVEILLANCE FILE NUMBER (SFN) CHANGE TESTS

Problem 1. The software does not allow a new unassociated discrete track (one that has not reached a firmness of seven) to become associated with an associated discrete track with a matching code during SFN change situations.

This problem was responsible for at least three track losses. Figure 11 shows one of the straight-line tracks and is an example of this type of problem.

Associated track AT03 with a firmness of seven starts out correlating with surveillance data having an SFN of two.

The current software design allows correlation with a new SFN only after five scans of missing data. In this example four scans of simulated misses occurred before data with a new SFN of 17 was received (in scan 50). Since five scans of misses had not occurred at this point, the AT03-associated track did not correlate with the new SFN. Since ARTS tracks every target, an unassociated track (no data block) was started on SFN 17.

Once the unassociated track was started, the AT03 track was not allowed to correlate with SFN 17 data, although AT03 had "opened up" for new SFN correlation after five scans of misses. Subsequently, AT03 dropped to tabular coast after 10 scans of misses, but it recovered in scan 58 after two scans, only because it is discrete.

Figure 12 shows a turning track and provides an example of problems 2 and 3.

Problem 2. The gross position check is a square area, aligned with the x-, y-axis, and centered upon the predicted track position. The target report received in the scan of the predicted track position is expected to fall within the square. If it does not fall within the square, it will not correlate with the track.

The square increases in size when a missed target occurs and continues to increase in size with each subsequent consecutive miss. A problem with design/logic occurs when one target report is received and correlates with the track after the square has grown in size due to two or more consecutive misses. When this one target correlates with the track, the square shrinks down to the original "no miss" size.

Associated track AT05 with a firmness of seven starts out correlating with surveillance data having an SFN of seven. The aircraft goes into a 90° turn. Nine target misses occur during the turn (beginning at scan 49), simulating a beacon fade. Ten scans later (scan 59), a target report is again received with the same beacon code but with a new SFN of 20. This target has a heading of 90° and is about 2 nautical miles (nmi) from the AT05-predicted track position for this scan (59).

Because of the nine consecutive misses, the gross position check box area has grown to a 10-nmi square, centered on the AT05-predicted track position, and AT05 correlates with the SFN 20 report. AT05 is then predicted to scan 60 with a firmness of three.

TRACK AT03
BEACON CODE 1303

LEGEND
+ TARGET POSITION (SFN = 2)
X TARGET POSITION (SFN = 17)
O ASSOCIATED TRACK POSITION
Δ UNASSOCIATED TRACK POSITION
F FIRMNESS
F1 LOWEST LEVEL
F7 HIGHEST LEVEL
S OPEN FOR NEW SFN

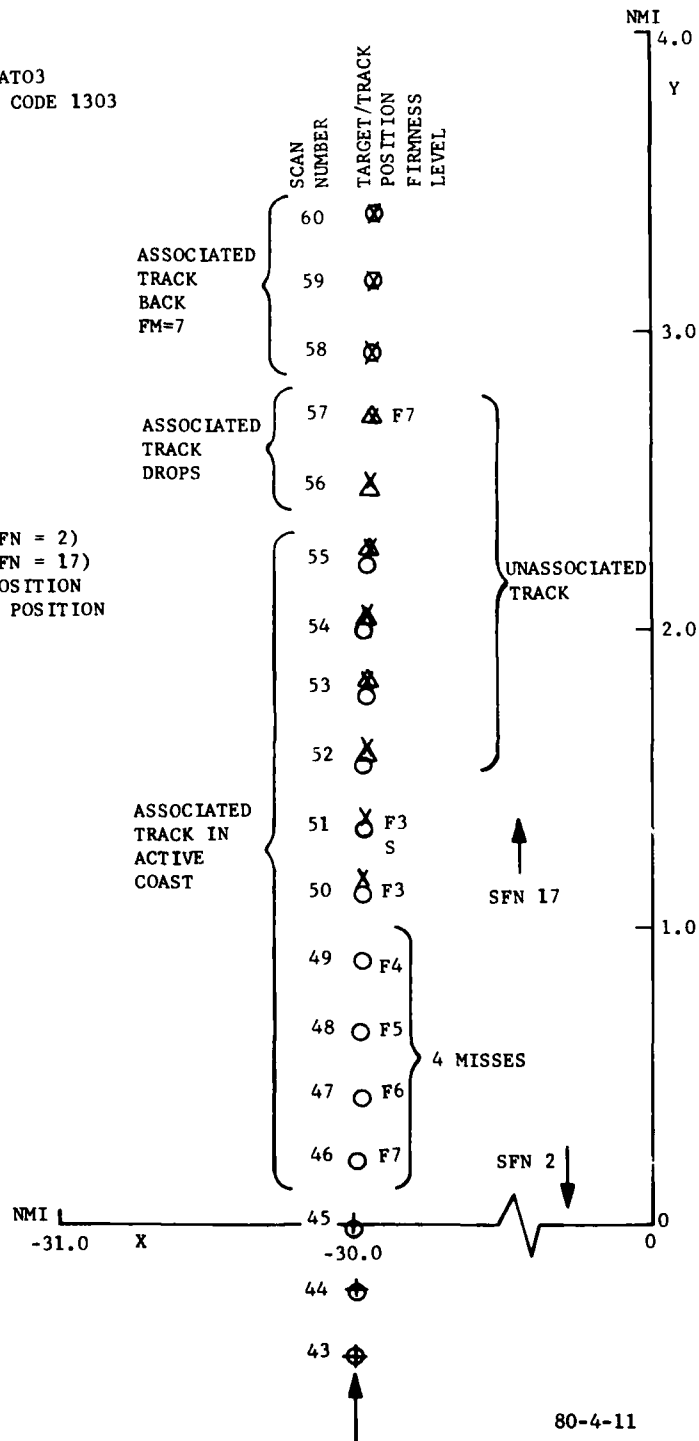


FIGURE 11. STRAIGHT-LINE TRACK—EXAMPLE OF PROBLEM 1

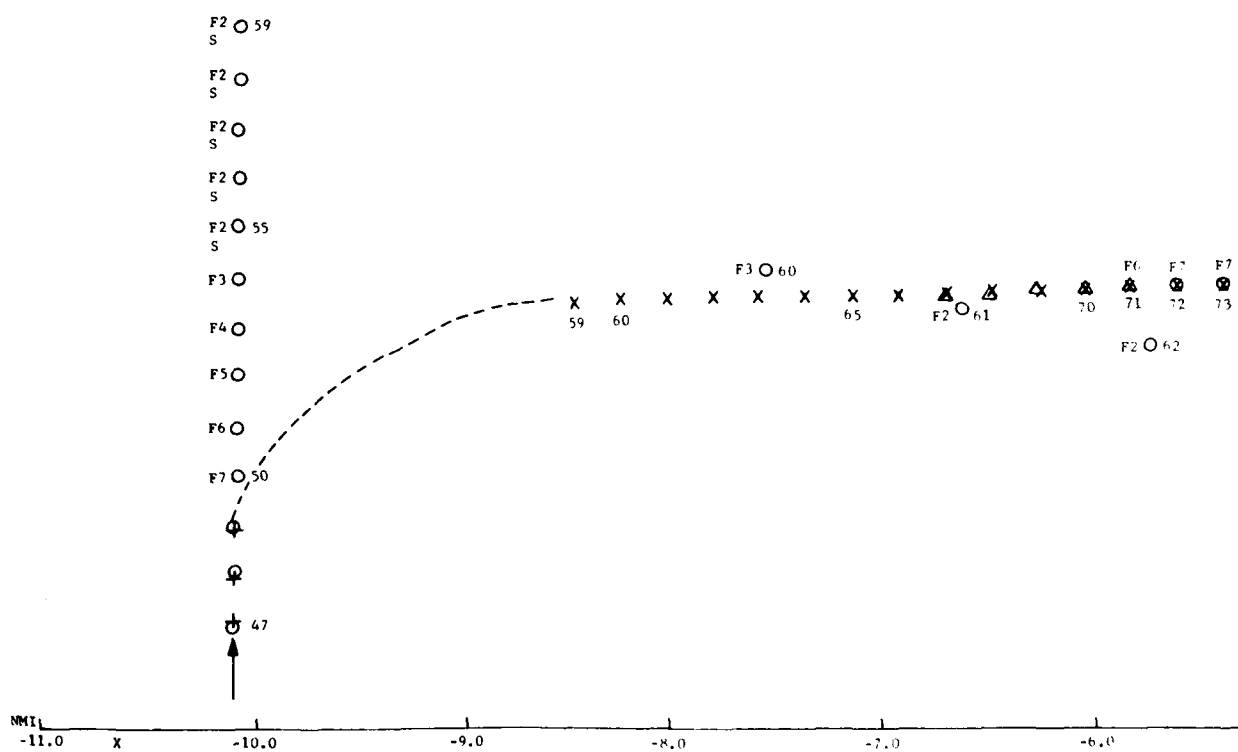
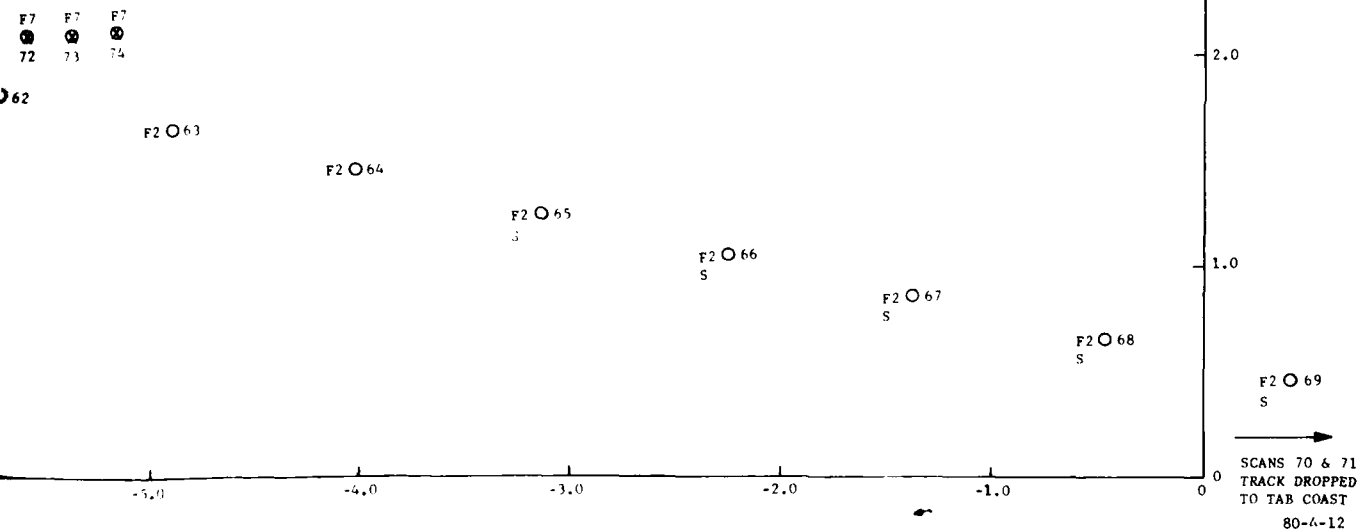


FIGURE 12. NINETY-DEGREE TURN

LEGEND
 + TARGET POSITION (SFN = 7)
 X TARGET POSITION (SFN = 20)
 O ASSOCIATED TRACK POSITION
 △ UNASSOCIATED TRACK POSITION
 F FIRMNESS
 F1 LOWEST LEVEL
 F7 HIGHEST LEVEL
 S OPEN FOR NEW SFN

TRACK AT05
 BEACON CODE 3505



FREE TURNING TRACK—EXAMPLE OF PROBLEMS 2 AND 3

At scan 60, another SFN 20 target is received. AT05 does not correlate with the target because the gross check area square centered around the predicted track position does not encompass the SFN 20 target, although the target is within 0.7 nmi of AT05-predicted position. Clearly, the gross position check area square decreased from a 10-nmi square to a 1-nmi square (the "no-miss" size) when AT05 correlated with the scan 59 SFN 20 target.

Problem 3. The TABG tracker may exhibit large velocity prediction errors after consecutive misses which result in track losses.

For example, in figure 12, during scans 61 through 68, track AT05, having a firmness level of two, actively coasts away from the target reported position at speeds of over 800 knots. At scan 59, nine consecutive misses had occurred, and the distance between the AT05-predicted position and the scan 59 SFN 20 target was already approximately 2 nmi. An apparent cascading effect occurs during subsequent scans of prediction of position and velocity. The causes for this phenomenon are not known with certainty and are being investigated.

The foregoing problems were discovered as a result of a detailed analysis of only three cases. In total, there were seven losses with the straight-line scenario and eight losses with the turn scenario. Investigations are continuing, and followup testing using the sensor is described later in this document. Information on both original and followup tests will be published in a MITRE Corporation working paper.

ATCSF/ARTS DELIVERY 2. Testing of ARTS Delivery 2 software using the ATCSF added another dimension to the DABS/ARTS testing, in that online testing with surveillance-related communications was included.

Analysis consisted of determining that surveillance performance was not adversely affected by the inclusion of CIDIN protocol and other software required for communications. Additionally, recorded communication messages were analyzed to assure that their contents were error-free, and that the proper message interchanges were occurring.

The surveillance-related messages tested were ATCRBS ID request, ATCRBS ID code, test and test response, and altimeter correction. Canned test messages were routinely transmitted from the ARTS DEEDS keyboard, and the proper test response was received from the ATCSF. This was determined from analysis of the communications data reduction. Altimeter correction notices were also transmitted by keyboard action, and the altitude was altered in the proper fashion. This was verified by data reduction.

The ATCRBS ID code message should be sent to ARTS whenever a DABS sensor receives a reply code from a DABS transponder containing mode 3/A codes. Such a reply may occur for the following reasons:

1. It is requested by a DABS interrogation in response to an ATCRBS ID request received from ARTS.

2. The mode 3/A code setting is changed.
3. The pilot has pushed his "alert" button indicating his wish to have his code readout.
4. The pilot has dialed a transponder adapted emergency code (e.g., 7600 or 7700).
5. The aircraft has been newly acquired by the DABS sensor.

Items 2 and 4 were simulated in the ATCSF for DABS targets by code changes at the simulator pilots' consoles. These actions were observed on the display by a flashing "AL" (alert), "RF" (radio failure), and "EM" (emergency). Analysis of the surveillance messages in the data reduction showed that the "alert" bit was set and that code changes did occur. Analysis of communications messages from the ATCSF to ARTS showed that, as a result of the ATCRBS ID request message, the proper ATCRBS ID code was transmitted. Subsequent tests to be conducted at a later date will provide data necessary to determine if the ATCRBS ID code message is sent for each of the cases outlined in 2 through 5 above.

The ATCRBS ID request message should be automatically initiated by available ARTS software when the following events occur:

1. A target report is received which does not correlate with an existing ARTS track.
2. A DABS class track is initiated or reinitiated after a coast; i.e., a "hit" after a "miss."
3. An ATCRBS ID message is received for an associated track with supplied beacon code (SBC) not equal to assigned beacon code (ABC).
4. An unassociated track is designated as an associated track.
5. Communications startup/startover occurs.

In addition, ARTS software sends an ATCRBS ID request message automatically every 30 seconds.

During testing, this last capability was made inoperable in order to facilitate analysis. Analysis of communications messages to date has revealed only that the ATCRBS ID request message was being transmitted but not why it was being transmitted.

Analysis of surveillance showed that surveillance performance did not change from the surveillance-only version of testing.

ARIES/ARTS DELIVERY 2. The introduction of the DABS sensor into the testing using ARIES inputs produced some results which suggest that further testing and analysis are needed. Results to date are given in the following paragraphs.

Track Initiation. Figure 13 shows the number of scans required to initiate ARTS tracks on ATCRBS and DABS targets. Only the first 10 scans are shown. Ideally, all tracks should be successfully initiated within three scans after the ARTS detects the targets (reference 7). Under ideal conditions using the ATCSF (see figure 9), this happened for 90 percent of the targets.

Using ARIES inputs through the DABS sensor provides more realistic conditions (e.g., code garbling) compared to the tests with ATCSF inputs.

In the "worst case" test segment with 68-percent reply probability, less than 40 percent of the ATCRBS tracks were initiated within three scans. Not shown in figure 13 for this case is the fact that nearly 20 percent of the ATCRBS targets never became associated with flight plan data, hence, tracks were never successfully initiated on them. This means that only about 40 percent of the ATCRBS tracks met theoretical expectations.

Even in the "best case" of 95-percent reply probability, only about 50 percent of the ATCRBS tracks met these criteria, and about 20 percent were never successfully initiated.

This poor performance can generally be attributed to two problems:

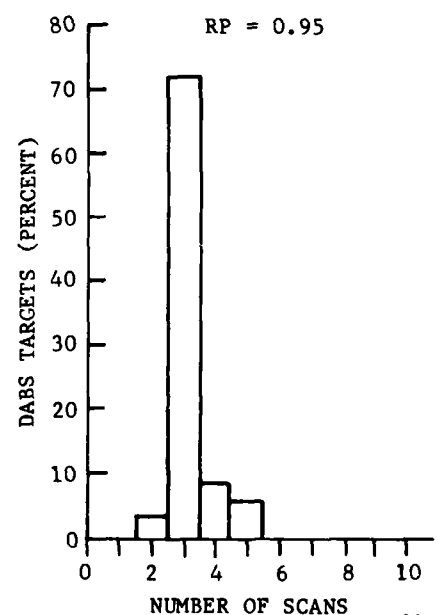
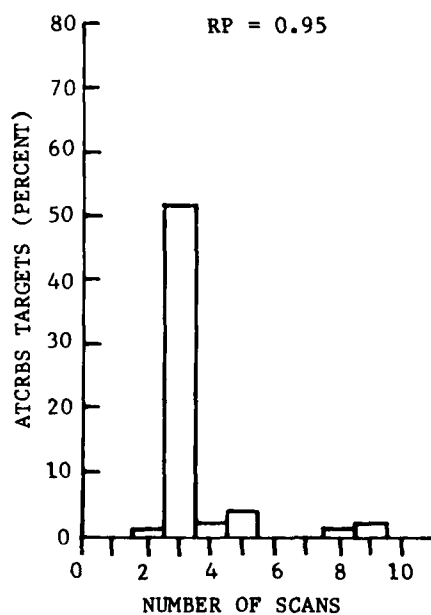
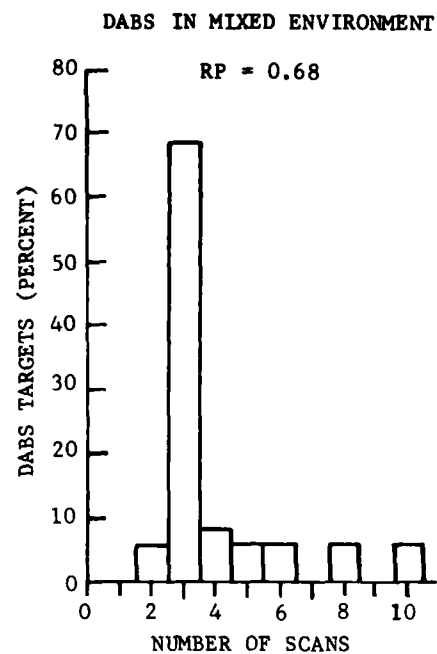
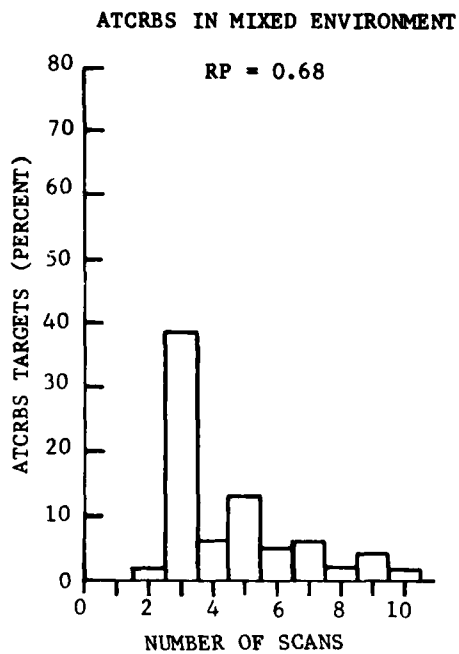
Problem 1. Simulated Calibrated Performance Monitoring Equipment (CPME) (stationary test target) arrives too late for the first test of a sequence of tests or test segments on a ARIES input tape.

Problem 2. Software errors—e.g., in some cases, tracking software appears to ignore valid surveillance messages received.

The first problem arises because ARTS sector processing software requires the appearance of the CPME before flight plan data can be associated with incoming targets. Test results show that track initiation performance is worse for the first test in the sequence indicating insufficient time for the CPME to be detected and, hence, for sector processing to begin.

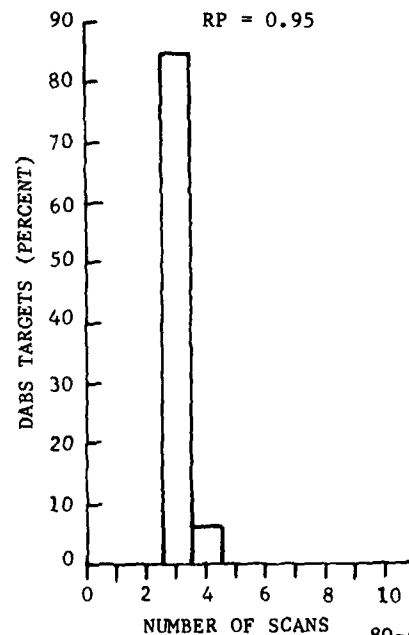
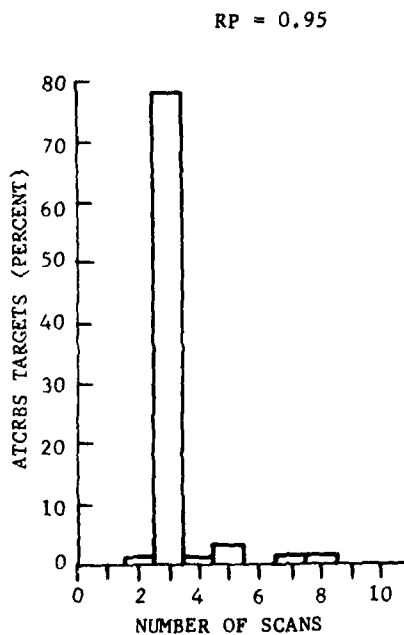
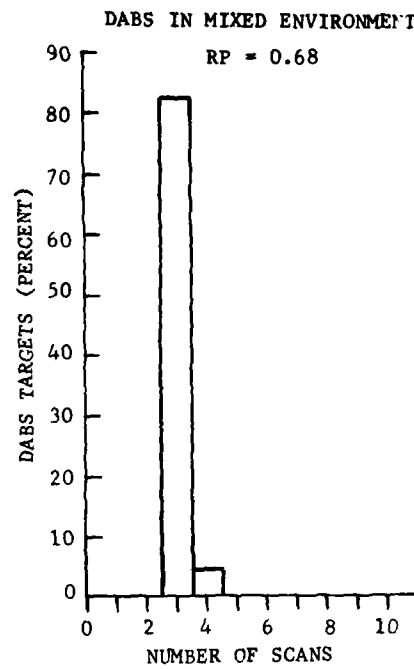
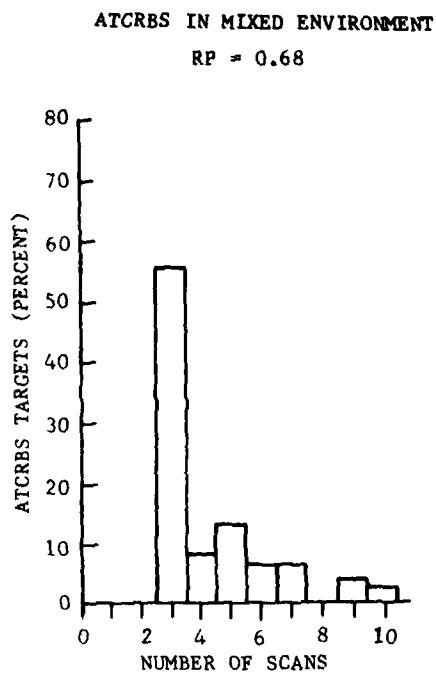
When results from this first test are excluded from the analysis, track initiation performance improves, as evidenced by results shown in figure 14. The number of targets which never become associated with flight plan data is now less than 10 percent in each case. This means that failure to associate is occurring during test segments other than the first. Analysis of data to pinpoint the causes for this will continue. As for the second problem, software errors are continuously reported and resolved.

One other situation warrants mentioning. Low-confidence mode C and mode 3/A occurred quite frequently. This is evidenced in the ARTS data reduction by incorrect code in the surveillance message and in the case of mode C, by the mode C bit not being set. While this situation does not affect track initiation as much as the above two problems, it apparently delays initiation by one or two scans.



80-4-13

FIGURE 13. NUMBER OF SCANS TO TRACK INITIATION—ARIES



80-4-14

FIGURE 14. NUMBER OF SCANS TO TRACK INITIATION—ARIES
(WITHOUT FIRST SCENARIO)

Track Swap. Track Swap evaluation to date has been conducted for the following cases:

1. Thirty-degree crossing, nondiscrete 3/A beacon track pairs with the same code.
2. Thirty-degree crossing mode 3/A beacon tracks with different codes (discrete and nondiscrete).
3. Thirty-degree crossing DABS tracks versus mode 3/A tracks.

During the latter two cases, as expected, there were no swaps observed for the two runs (68 percent and 95 percent) conducted. For the first case, however, five swaps occurred for the run with reply probability of 68 percent, and three swaps occurred for the run with 95 percent.

Track Loss. Except for tests with SFN changes at which track losses were directly observed, track loss evaluation is incomplete. This is due to another software problem manifested by a firmness drop from seven to two in one scan which could affect track loss. The problem is under investigation.

SFN Change Tests. During the SFN change tests, two straight-line scenarios were generated: one with 13 nondiscrete targets, and one with 13 discrete targets. Both scenarios are similar to the ATCSF straight-line scenario shown in figure 11, with similar numbers of consecutive misses simulated. The scenarios were run with 95-percent reply probability. The scenarios will be repeated in the future with 100-percent reply probability. Additionally, one nondiscrete and one discrete turn scenario, similar to the ATCSF scenario, will be generated for ARIES and run in future tests.

Four nondiscrete tracks were lost permanently in nondiscrete straight-line scenario. Five discrete tracks were lost temporarily to tabular (TAB) coast. In general the SFN's did not change unless there were five or more consecutive target misses. However, in one case an SFN changed within two scans causing problems for the ARTS tracker. More testing is needed before any conclusions are made about SFN sensor changes.

Surveillance-Related Communications. The objectives and procedures in testing surveillance-related communications with ARIES inputs were the same as those delineated under the section entitled, ATCSF/ARTS DELIVERY 2.

During testing and analysis with ARIES data, it was discovered that the lack of a procedure for providing beacon codes in the flight plan data of DABS class tracks caused problems. As no beacon code could be entered either via the magnetic tape flight plan program (Bulk Store) or via ARTS III target generator scenario program, a code consisting entirely of zeros was assigned.

Consequently, when an ATCRBS ID code message was transmitted downlink to ARTS (i.e., the supplied beacon code), it was never equal to the assigned beacon

code. This caused a loop which eventually tied up the communications channel. The problem was alleviated only by a manual "implied assign beacon code modify" entry at the keyboard.

Except for this problem, communications messages were transmitted and received in accordance with CIDIN protocol. Test and test response and status messages were transmitted without error.

SUMMARY OF RESULTS

The results of the tests conducted to date to characterize the technical performance of the Discrete Address Beacon System (DABS) in an Automated Radar Terminal System (ARTS) environment are summarized below:

1. Tests conducted in the evaluation area of ARTS track initiation, track loss, and track swap using Air Traffic Control Simulation Facility (ATCSF) inputs showed successful initiation occurring 90 percent of the time while there were no track losses or track swaps.
2. Special tests conducted to determine ARTS reaction to DABS sensor surveillance file number (SFN) changes led to the identification of problems in the ARTS tracker software which caused track losses.
3. Tests of surveillance-related communications using ATCSF inputs showed that as a result of ATCRBS Identification (ID) request messages transmitted by ARTS, DABS sensor ATCRBS ID code message responses were properly simulated by the ATCSF with the correct code.
4. Code changes (including emergency and radio failure) implemented at the ATCSF, properly set bits in the surveillance messages transmitted to ARTS, and indications that the ATCSF/ARTS interchange had occurred were observed on ARTS displays.
5. Tests using Aircraft Reply Interference and Environment Simulator (ARIES) inputs through the DABS sensor had mixed results. ARTS track initiation performance was found to be highly dependent on the timely arrival and proper orientation of the required stationary test target from the Calibrated Performance Monitoring Equipment (CPME). Performance was improved by 15 percentage points when the results of testing the "worst case" first scenario on an ARIES tape were excluded.
6. Track swaps were observed for nondiscrete ATCRBS track pairs.

CONCLUSIONS

Based on the results to date of the test and evaluation of the combined Discrete Address Beacon System (DABS) Automated Radar Terminal System (ARTS) systems, it is concluded that:

1. The modified ARTS software is capable of accepting and processing DABS inputs.
2. Technical performance of the systems can be greatly affected by the timeliness and orientation of the Calibrated Performance Monitoring Equipment (CPME) target periodically required by ARTS.
3. Surveillance file number (SFN) changes in the DABS sensor can lead to track losses at ARTS.
4. Known software problems must be resolved before surveillance performance with realistic inputs can be completely specified, and further tests are required before DABS/ARTS performance in surveillance-related communication can be characterized.
5. ARTS software problems affected track initiation and track loss performance.

RECOMMENDATIONS

It is recommended that steps be taken to:

1. Provide an alternate procedure for synchronizing the Automated Radar Terminal System (ARTS) Terminal Automation Test Facility (TATF) with the Discrete Address Beacon System (DABS) antenna in lieu of periodic stationary test targets.
2. Provide sufficient information on surveillance file number (SFN) changes in the DABS sensor so that the SFN change parameters in the ARTS software can be made as realistic as possible.
3. Provide some means of identifying printed ARTS data reduction resulting from data extractions which were not used in the Thresholded Alpha Beta Gamma (TABG) tracking equations.
4. Investigate ARTS tracker software in light of the discovery of problems due to sensor SFN changes.
5. Eliminate the requirement that Air Traffic Control Radar Beacon System (ATCRBS) identification (ID) request messages be transmitted every 30 seconds or any other frequency which duplicates the results of unsolicited ATCRBS ID code messages.

6. Provide in the communications messages in the data reduction some means of distinguishing between unsolicited ATRBS ID code messages and those transmitted as a result of ATRBS ID code requests.

7. Provide some means of assigning beacon codes in the flight plan data for DABS class tracks.

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